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which comes much later in the history of reduction, after the spirem has undergone an enormous amount of shortening and thickening. In *Oenothera* it is a well-marked stage, immediately preceding the transverse segmentation of the spirem to form chromosomes; and separated from synizesis by a long interval, during which the spirem loosens its coils, enabling the rearrangement and thickening of the threads to go on.

The author's account of the heterotypic chromosomes in *O. grandiflora* shows an evident difference between this species and the *O. Lamarckiana* forms. In the former, rings are said always to be produced, although no adequate evidence of their method of origin is presented. While it is probable that many of the rings figured are really open at one end, or with the chromosomes merely in contact and not fused, yet a comparison of DAVIS's *figs.* 27-30 with my *figs.* 26-34 (*O. rubrinervis*, '08) shows that evidently the attraction which leads a chromosome to pair with its mate is greater in *O. grandiflora* than in *O. Lamarckiana* forms. This condition in *O. Lamarckiana* forms may have come about as a result of conditions of cultivation or hybridization, and, as I have pointed out elsewhere, may be directly connected with the mutation phenomena in *O. Lamarckiana*. Whether or not this is the case, I have shown that, as a result of this weak attraction between chromosomes, irregularities in chromosome distribution during reduction actually do occur.—R. R. GATES.

Cytology of the ascus.—BLACKMAN and Miss FRASER,¹² and more recently Miss FRASER¹³ and Miss WELSFORD,^{14, 15} have concluded that in *Humaria granulata*, *Ascobolus furfuraceus*, and *Lachnea stercorea* a normal sexual process does not obtain. Instead of a fusion of sexual nuclei in the oogonium, a reduced sexual process occurs in which the female nuclei fuse in pairs with a subsequent asexual fusion in the ascus.

Still more recently FRASER and BROOKS¹⁶ have studied further the process of nuclear division, methods of chromosome reduction, and spore formation in the above-mentioned pseudo-apogamous forms. They find in each of these plants two sorts of reducing divisions occurring in the ascus. The first two divisions are heterotypic and homeotypic respectively, and thus bring about a chromosome reduction in the manner described for higher plants. They regard this type of reduction as being associated with fertilization or its equivalent. The third

¹² BLACKMAN, V. H., AND FRASER, HELEN C. I., On the sexuality and development of the ascocarp of *Humaria granulata*. Proc. Roy. Soc. London B 77:354-368. 1906.

¹³ FRASER, HELEN C. I., On the sexuality and development of the ascocarp of *Lachnea stercorea*. Annals of Botany 21:349-360. 1907.

¹⁴ WELSFORD, E. J., Fertilization in *Ascobolus furfuraceus*. New Phytol. 7:156-161. 1907.

¹⁵ FRASER, H. C. I., AND WELSFORD, E. J., Further contributions to the cytology of the Ascomycetes. Annals of Botany 22:465-477. 1908.

¹⁶ FRASER, H. C. I., AND BROOKS, W. E. ST. J., Further studies on the cytology of the ascus. Annals of Botany 23:537-549. 1909.

division of the ascus nucleus, which differs little in appearance from the normal vegetative type of division, is described as brachymeiotic, in which half the heterotype number of chromosomes is present, thus bringing about, as is believed, a second reduction in the number of chromosomes. In *Ascobolus jurfuraceus* and *Humaria granulata* they find that the eight chromosomes are paired throughout the second and also in the prophases of the third division. In *Lachnea stercorea*, in which the meiotic prophases were studied more in detail, the heterotype number of chromosomes is four, two chromosomes being much longer than the other two. The first numerical reduction occurs by an end-to-end union of the chromosomes, which are subsequently separated transversely. In the third metaphase four chromosomes are present. Two entire chromosomes, one long and one short, pass to each daughter nucleus.

Brachymeiosis is believed to differ markedly from meiosis in several particulars. In meiosis it is held that the most essential feature seems to be the union of two chromosomes to form so-called gemini, while brachymeiosis may be accomplished without visible union of the chromosomes, as described for *Lachnea stercorea*, and when pairing does occur in this division, as described for *Ascobolus jurfuraceus* and *Humaria granulata*, the opportunity for interchange of material is held to be much less than in meiosis. It is believed, therefore, that it is possible to distinguish between sexual and asexual fusions by a study of the subsequent reduction divisions. (The reviewer cannot agree with these authors that the distinguishing characteristic of meiosis, at least the visible distinction, rests on the close association of the chromosomes. The conspicuous fact is the formation of tetrads or so-called four-parted chromosomes. The formation of tetrads does not necessarily imply any very close association of the constituent parts of two-parted chromosomes.)

In the opinion of the authors the parental allelomorphs and also those brought together by the nuclear fusion in the ascus may show varying degrees of association, and this is brought out by a text figure, in which the forms here studied are compared with several other Ascomycetes. In *Humaria granulata* pairing of the chromosomes is present in the pre-meiotic divisions, while this pairing occurs in the meiotic prophases in *Ascobolus jurfuraceus*, thus resembling *Otidea aurantia* and *Peziza vesiculosa* in this respect.

The authors also find that an important part is played by vacuoles in spore delimitation. They find in *Ascobolus* a differentiation into dense and vacuolated areas, but also that the center and astral rays are essential to spore delimitation. After the third division the cytoplasm becomes traversed by an irregular series of vacuoles or areas of cleavage, which separates the sporeplasms. It is held that a substance flows out from the center, capable of producing alterations in the cytoplasm, probably an enzyme. A definite membrane is put about the sporeplasm, and a similar one limits the neighboring periplasm, with a clear space between, marking the old lines of cleavage. Although these observations support FAULL's views, they also support the view that the astral rays play an important part in spore delimitation.—J. B. OVERTON.